REMARKS

Favorable consideration of this application as presently amended and in light of the following discussion is respectfully requested.

Claims 7-13 are pending in the application, with Claims 7 and 12-13 amended by the present amendment.

In the outstanding Office Action, the specification was objected to; Claims 7-13 were rejected under 35 U.S.C. § 112, first paragraph; Claims 7 and 9-13 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Street et al. (U.S. Patent No. 5,117,114, hereinafter Street); Claim 8 was rejected under 35 U.S.C. § 103 as being unpatentable over Street in view of Morton (U.S. Patent No. 5,693,947); Claims 7 and 9-13 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Takahashi et al. (U.S. Patent No. 5,164,973, hereinafter Takahashi); Claim 8 was rejected under 35 U.S.C. § 103 as being unpatentable over Takahashi in view of Morton; Claims 7 and 9-13 were rejected under 35 U.S.C. § 103 as being unpatentable over Shaw et al. (U.S. Patent No. 4,338,521, hereinafter Shaw); Claim 8 was rejected under 35 U.S.C. § 103 as being unpatentable over Shaw in view of Morton.

Claims 7 and 12 -13 are amended in response to the rejection under 35 U.S.C. § 112, first paragraph. Claims 7 and 12-13 are amended to recite that a plurality of emitters. As noted in the Official Action, support for this amendment is found in Applicants' originally filed specification.1 No new matter is added.

Briefly recapitulating, Claim 7 is directed to a semiconductor detector for use in a high-speed X-ray CT. The detector includes a plurality of detector modules each comprising a plurality of X-ray detection pixels arranged unidirectional on a single planar semiconductor

substrate. The plurality of detector modules is arranged polygonally around a circumference of a measuring area and is placed opposite an emitter. The emitter is located outside the circumference of the measuring area. With this configuration, it is unnecessary to discretely arrange detection pixels or to have a drive portion to move the emitter. Thus, the claimed inventions provide for less complicated, less expensive, and longer-lived devices than conventional detectors.[2]

By way of background, the present invention relates to the fast scanning X-ray CT system which is able to complete a cross section scanning within a few milli-seconds to capture the internal structure of a dynamic event. This fast scanning capability is achieved by using a combination of fixed high-efficiency detector modules and multiple pulse X-ray emitters. Contrary to conventional X-ray CT systems, the present system has no mechanical moving parts. The cross section scanning is made by electrical switching of the open gate of each pulse X-ray emitter, together with simultaneous data collection for each X-ray emission. Since emission period of X-ray for each emitter is on the order of a hundred micro seconds, detector should be highly sensitive, which leads us to choose high efficiency detector materials, such as CdTe. The sequential emission of pulse X-rays of the devices such as Applicants' claimed invention is an improvement over the mechanical scanning motion of the rotatable gantry used in the 3rd generation CT systems. The reduction of the scanning time by the electrical switching is enormous and the scanning time is reduced to about 1/100 of the conventional X-ray CT systems in which a combination of an X-ray source and a detector mounted on a rotatable gantory rotates around imaging area, classified as the 3rd generation systems. Thus, in Applicants' claimed inventions, a sequential firing of multiple pulses X-ray

1 Specification, page 8, lines 7-16.

emitters, not rotation, is used for a cross section scanning. For the Examiner's convenience, details of a fast scanning X-ray CT system are shown in Misawa et al., Kerntechnik 68 (2003) 3 pp.85-90, which antedates Applicants' inventions and is attached to this reply.

Constitution of the fast scanning X-ray CT system described in the present invention is indispensable for realizing drastic reduction of scanning time, which is entirely different from the constitution of Takahashi. Applicants note that the detector modules of the present invention are fixed along an arc whose center matches the center of the circular measuring area, unlike those of Takahashi, Street, and Shaw, all of which belongs to the 3rd generation CT scanner. The above difference leads to the angle between the two adjacent detector modules of the present invention much smaller than those of Takahashi, Street, and Shaw. Such arrangement of detector modules is unique to the fast scanning X-ray CT and becomes inappropriate for the 3rd generation systems in which a combination of a single X-ray emitter and detectors rotates around the measuring area. To use the present arrangement of detector modules effectively, X-ray emission angle should be changed as the sequential X-ray emission progresses.

In summary, the differences of the detector modules between the 3rd generation CT systems and the fast scanning CT systems are as follows:

1) Regarding the center location of the arc along which each detector module are tangential: conventional 3rd generation CT systems do not match the center of the measuring area so that the location of the X-ray emitter is the center of the arc, whereas fast scanning X-ray CT systems, such as Applicants' inventions, do match the center of the measuring area.

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[2] Specification, page 5, lines 6-12.

2) Regarding the angle between the adjacent detector modules: conventional 3rd generation CT systems have a large angle, whereas fast scanning X-ray CT systems have a small angle, which makes the curvature of the above arc different to each other.

3) Regarding the length of the arc along which each detector module are tangential: in conventional 3rd generation CT systems the length of the arc extends over the measuring area projection, whereas in fast scanning X-ray CT systems the length of the arc extends over (180 degree + half angle of the X-ray fan beam), which is appropriate for short scanning.

With this background, it is now possible to distinguish the claimed inventions from the cited references.

Street discloses a radiation detector including an X-ray tube 211 that emits a radially directed beam 212 to a target.[3] The X-ray tube is *rotated* around the target.[4] Also, by inspection of the Figures, the X-ray tube of Street is located within a circumference circumscribed by the detectors. However, Street does not disclose or suggest a plurality of detector modules arranged around a circumference of a measuring area such that an emitter is located *outside* the circumference, as recited in Claims 7 and 12. In Street, the detector modules are arranged such that the emitter is located *within* the circumference. In addition, in Street the emitter *rotates* around the target. Therefore, the device of Street suffers the same limitations as Applicants Admitted Prior Art relative to mechanically rotating emitters/detectors.[5] That is, Figure 11 of Street is characteristic of the previously discussed

[3] Street, Figure 11.
[4] Street, column 9, lines 35-44.
[5] Specification, page 2, lines 8-11.

3rd generation CT systems, and therefore cannot complete a single scan in a few milli-seconds as is possible with Applicants' invention. Also, Street does not disclose or suggest an angle between the adjacent detector modules for completing fast scanning as required for fast scanning X-ray CT corresponding to Applicants' invention.

Takahashi discloses a projection detecting apparatus for computer tomography.[6] Like Street, the device of Takahashi includes a detector and an emitter that are jointly *rotated* around the object to be inspected.[7] Also, by inspection of the Figures, the emitter of Takahashi is located within a circumference circumscribed by the detectors. Thus, like Street, Takahashi does not disclose or suggest a plurality of detector modules arranged around a circumference of a measuring area such that an emitter is located *outside* the circumference, as recited in Claims 7 and 12.

Shaw discloses a *rotable* tomographic apparatus including a modular detection array.[8] Also, by inspection of the Figures, the emitter of Shaw is located within a circumference circumscribed by the detectors. Thus, like Street and Takahashi, Shaw does not disclose or suggest a plurality of detector modules arranged around a circumference of a measuring area such that an emitter is located *outside* the circumference, as recited in Claims 7 and 12. Also, detector module 46 in Figure 3 of Shaw shows that Shaw is another example of conventional 3rd generation CT systems. In 3rd generation systems, the X-ray direction against the detector modules are always the same, while in the fast scanning CT systems, the X-ray emission direction relative to the detector modules changes as each X-ray emitter is activated.

Therefore, as none of the cited prior art, individually or in combination, disclose or

[6] Takahashi, column 2, lines 28-34.
[7] Takahashi, Figure 2.
[8] Shaw, column 2, lines 44-56 and Figure 1.

suggest all the elements of independent Claims 7 and 12, Applicants submit the inventions defined by Claims 7 and 12-13, and all claims depending therefrom, are not anticipated and are not rendered obvious by the asserted prior art for at least the reasons stated above.[9]

Regarding Claim 8, Applicants note that Street discloses a photolithography technique for silicon.[10] Morton discloses that pixel fabrication of Fig.5 and Fig.7 is possible using normal silicon processing techniques.[11] Morton also discloses12 that "Fig.6 *could* [emphasis added] be replaced by a single layer of a radiation conversion material...." However, Morton does not disclose or suggest a process taking into account of physical and mechanical properties of CdTe substrate, which is different from those of silicon. Applicants submit that CdTe detector devices cannot be made just by applying silicon process directly because of different material characteristics. Thus, Applicants' submit that applying normal silicon process to CdTe is NOT obvious to "a person having ordinary skill in the art to which said subject matter pertains." For example, it is not possible to make pn junction by injecting p-type impurity and n-type impurity, like for silicon.[13] Applicants submit it is not yet possible to form an FET on CdTe which is indispensable for switching. In addition, since CdTe is more fragile than silicon, wire bonding technique commonly used in silicon process cannot be applied. Thus, contrary to the disclosure Morton,[14] it is impossible to apply the normal silicon process to CdTe which has different properties. Furthermore, in Morton, the time constant shown in equation (4) in lines 19-24 of column 4 is preferred to be large for the

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[9] MPEP § 2142 "...the prior art reference (or references when combined) must teach or suggest **all** the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on applicant's disclosure. In re Vaeck, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991)."
[10] Street, column 4, lines 35-42.
[11] Morton, column 8, lines 24-26.
[12] Morton, column 8, lines 58-64.
[13] Morton, column 7, lines 15-23.

constitution of the detector for 3rd generation CT systems. However, the above requirement contradicts that of the fast scanning CT of the present invention. Use of CdTe device is accordingly required as we pursue highly sensitive detector material to compensate short irradiation period of X-ray.

With regard to Shaw, as noted in the Official Action, the integrated circuit 96 of the straight modules 46 is made via photolithography. However, Applicants submit this disclosure is not pertinent to Applicants' claimed inventions since photolithography techniques used for the integrated circuit and print circuit board are totally different from that used for detector pixels. As shown in Fig. 8 in Shaw, module 46 is made of semi-conductor chip 96 consisting of individual scintillator crystal and photo diode, in which a small gap exists between individual crystals. In Applicants' invention, however, pixels formed on a single substrate of CdTe have no gap between them, resulting in higher spatial resolution. Although the photo diodes can be integrated into semi-conductor chip 96, the CdTe crystal cannot be a part of the chip. CdTe substrates always reside outside the chip and are wired to a signal processing unit in a chip by a special bonding technique which is not an extrapolation from normal silicon bonding/process.

For the above reasons, Applicants submit there is no teaching, suggestion, or motivation, either explicitly or implicitly, in either reference to combine the photolithography technique of Shaw or Street with the pixel fabrication techniques of Morton to arrive at Applicants' inventions recited in Claim 8. Thus, Applicants submit it is only through an impermissible hindsight reconstruction of Applicants' invention that the rejection of Claim 8

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[14] Morton, column 10, lines 43-46.

can be understood.[15] Furthermore, Applicants submit that the combination of Shaw or Street with Morton would be inoperative for at least the reasons cited above.

Accordingly, in view of the present amendment and in light of the previous discussion, it is respectfully submitted that the application is believed in condition for allowance and early and favorable action to that effect is respectfully requested.

Respectfully submitted,

OBLON, SPIVAK, McCLELLAND,
MAIER & NEUSTADT, P.C.

Gregory J. Maier
Registration No. 25,599
Attorney of Record
Michael E. Monaco
Registration No. 52,041

Customer Number
22850
(703) 413-3000
(703) 413-2220 (fax)
GJM/MEM/kkn
I:\ATTY\MM\AMENDMENT\163\218866.AM.DUE AUGUST 6..DOC

[15] MPEP § 2143.01 "Obviousness can only be established by combining or modifying the teachings of the prior art to produce the claimed invention where there is some teaching, suggestion, or motivation to do so found either explicitly or implicitly in the references themselves or in the knowledge of one of ordinary skill in the art."